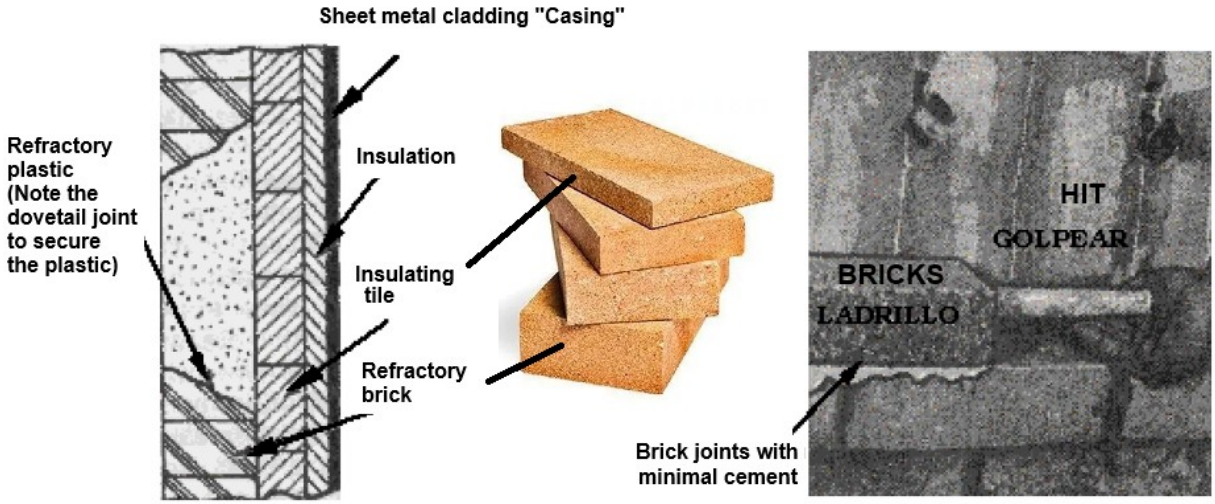
CHAPTER 23: REFRACTORIES

Boiler refractories must be repaired by individuals with refractory expertise ("fume fitters").

Expansion joints and the method of joining pieces must be carried out with expertise in the subject.

The materials to be used must be purchased and supplied according to the location and method of use (they vary with temperature, temperature variations, and the repair method).

All refractory materials that have been installed must be dried very slowly (except for refractory plastics for quick repairs) and over a low heat. Some refractories must be fired at high temperatures; others have already been fired in special kilns, as is the case with refractory bricks or other refractory pieces.



LEAVE EXPANSION JOINTS IN APPROPRIATE AREAS
THE INSULATION OF THE SHEET METAL (CASING) IS ESSENTIAL
THE "SPACE" BETWEEN BRICKS SHOULD BE AS SMALL AS POSSIBLE

When using "plastic" materials (refractories for quick repair), they must be perforated to allow steam to escape from the inside (otherwise, they will crack due to the internal pressure of the steam that forms).

When welding supports for the refractories (anchors), in very hot areas, they should be made of stainless steel (for high temperatures) and wrapped with a combustible material to allow for some play to absorb the metal's expansion; otherwise, they will stress the refractory material until it cracks.

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Refractories themselves are not insulators; their function is to withstand the high temperatures generated during combustion (generally to protect the insulating material, which in turn protects the metal; they are very dense, meaning they are heavy).

Therefore, insulating materials must be placed between the metal and the refractory material (such as insulating brick, a very lightweight material; mineral wool, field brick, asbestos, vermiculite—the latter two are considered carcinogenic, and some vermiculites may contain asbestos fibers, etc.).

Areas that are exclusively enclosed by refractory material and that do not have water cooling (such as in water-tube boilers or tube "chapels", whether in liquid, gaseous or wood-fired boilers) must be insulated with some caution if the temperature is high or if it is in contact with combustion, since an excess of insulation does not allow the temperature "gradient" necessary to prevent the refractory mass from reaching the same temperature as the combustion, which causes deterioration of the refractory and sometimes deformation of the anchoring system.

Refractories in boilers (whose combustion tends to be acidic) are generally made of acidic materials (such as silica and aluminum in combination with other elements).

Alkaline refractories (generally based on magnesium or calcium) are also used, typically in some types of furnaces (which mix fuels with alkaline elements, such as lime kilns).

All of this means that we must respect the use of acidic refractories with acidic combustion characteristics. Otherwise, if we were to use a refractory material that is different from the characteristics of the environment, a reaction would occur that causes the refractory to deteriorate (acids combine with alkaline elements and cause deterioration).

There are materials better suited for emergency repairs, which cannot be left to set for a while, such as "plastic" refractory clay (this material is kneaded, with almost no water, like putty, so that it can be formed into a ball without cracking).

This material should be applied to areas that have been previously prepared so that it creates its own anchor (like a dovetail joint or what a dentist does to place amalgam). When applying the material, it is tapped with a mallet ("tapped").

Then, small holes are made with a thin steel wire (to allow the steam that forms inside when heated without drying to escape). This material can be heated gently immediately until cooked.

Concretes (of the concrete type) must be poured as if they were regular concrete and require a setting and drying time, followed by a very slow firing of several hours to reach working temperature.

If a metal frame is placed inside, it must be covered with a material that will burn (paper tape wrapped around the iron, tar, or another material that forms a layer). This thickness, as it disappears, allows the metal to expand without breaking the refractory material.

To create "screens" or protect the pipes from direct fire, special refractory materials (such as chrome-ore) are used. These are placed over the pipes, which have "pins" or "docks" (sometimes made of stainless steel) to which the refractory material is anchored.

Expansion must be carefully considered to prevent the refractory material from cracking due to excessive pressure.

The expansion grooves (formed with combustible materials such as cardboard, wood, synthetic foam, etc.) must be sealed with a bead of asbestos (a type of asbestos that is more silky, now banned and replaced by materials with similar mechanical and thermal resistance, such as mineral wool) after the materials have burned.

This prevents small fragments of the refractory material from entering the groove, which, once filled, would reduce its capacity to allow for expansion.

EXPANSION TO CONSIDER FOR EACH REFRACTORY MATERIAL	Thermal Expansion 0-1400°C	Inches per Foot
95% Silica Bricks	1.25%	5/32
Firebricks	0.75%	3/32
High Alumina (50-60% Al_2O_3)	**0.8%**	**3/32**
High Alumina (over 60% Al_2O_3)	**0.9%**	**1/8**
Magnesite Bricks	1.74%	1/4
Chrome-Magnesite Bricks	1.38%	3/16
Unburned Magnesite Bricks	1.5%	3/16
Unburned Chrome-Magnesite Bricks	1.2%	5/32
Chrome Bricks	1.16%	5/32

Cold drafts should be avoided on refractory materials, as they cause cracking.

The more "high-temperature rated" the refractory material is, the more care must be taken to protect it from cold drafts.

These cold drafts cause cracks in these very hard and high-density materials. Therefore, softer materials, i.e., those with a lower silica or alumina content, should be placed over the loading openings.

When installing refractory bricks or pieces, **while expansion gaps must be left, the bond between them is achieved with a very thin cement base** (this differs from a common brick wall, where the assembly relies on interlocking the pieces rather than filling the joints, since too much cement tends to loosen and cause the wall or arch to collapse).

The arches must be constructed with the appropriate pieces ("blades") at the necessary angles to close the arch with minimal use of cement. This is crucial, as the arch will move due to the expansion and contraction caused by varying combustion or cooling temperatures.

A boiler or furnace with a large amount of refractory material should be cooled slowly and not by force using forced air, as this would be very detrimental to the refractory material.

Another problem to consider with refractory materials is their high weight (their high density or weight per unit volume: kg/dm^3).

This means the support base must be adequate to bear this weight, especially considering that corrosion or deterioration of the metal structures will occur over time.

Hot refractory materials should not be wetted with cold water. Hot water can be used if necessary, provided the refractory temperature is already relatively low.

Therefore, if installing a combustion suppression system, ideally a steam injection system should be used, not water (but if water must be used, it should be a mist, not a jet).

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Refractory material is often used to protect exposed parts of the boiler from excessive heat. Otherwise, these parts would not only "burn" from the direct radiant flame, but excessive heat transfer would also cause poor internal water circulation, leading to problems in that area or elsewhere.

Examples of elements protected from excessive heat:

a- Horizontal collectors: Two factors necessitate insulation here: the thickness of the metal, which hinders cooling, and the horizontal position, which impedes the evacuation of any steam that may form. Internal circulation can be affected because the mass of water is displaced to a much larger volume, reducing water circulation.

b- Some parts, such as gas generators, whose internal circulation can be inherently difficult if steam forms (remember that 1 kg of water at 10 kg/cm² occupies a volume 180 times greater when it vaporizes, which reduces the circulation of the internal water mass, preventing sufficient cooling of the gas generator, both tube and jacketed types);

c- Areas exposed to very intense radiation (such as screen tubes or baffles);

d- Domes and collectors exposed to radiant areas (given the thickness of the metal and its poor conductivity, proper cooling is not possible).

'PERCENTAGE CHEMICAL COMPOSITION OF REFRACTORY BRICKS
(M.R. Villanueva)

Brick Class	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	Cr_2O_3	Oxides Secondary
Primary Silica	94 a 97	1 a 2	0,5 a 1,5	2 a 3,5	—	—	1,5 a 2,5
Secondary Silica	92 » 94	1 » 5	0,5 » 1,5	2 » 4	—	—	1,5 » 2,5
Refractory Clay (1)	50 » 65	32 » 45	0,8 » 3	0 » 0,5	0,2 a 0,5	—	5 » 6
Semi-acidic Chamotte	65 » 85	12 » 32	0,8 » 3	0 » 0,5	0,2 » 0,5	—	4 » 7
Magnesite	2 » 6	1 » 2	4 » 8	1 » 2	83 » 89	—	5 » 10
Chromite	3 » 6	15 » 33	—	—	14 » 18	30 a 45	—
Regulatory for the Navy (2)	40 » 56	40 » 46	1,8	0,5	0,3	—	—

(1) Basic Chamonite
(2) Alumina and clay. They also contain, at most: titanium 2%; alkali 0.7%. Melting point: above 1720 °C. They are used for oil furnaces."

Refractory material is also used to raise the temperature of the firebox in certain areas, improving combustion (since it is a poor conductor of heat, provides protection, and has high density, accumulating and reflecting heat).

This applies both to the burner area (serving a dual function: protecting and stabilizing the flame through radiant heat from the burner itself) and to the combustion end zones, preventing excessive flame cooling, which would extinguish the flame below a certain temperature (producing soot, unburned gases, etc.).

Boiler Repairs:

When we talk about repairs, we might think of something simpler than building a boiler, but this isn't the case:
A repair of the casing, plate, or firebox is a much more serious undertaking.

These repairs must be carried out by authorized workshops, with subsequent inspections (visual inspection, X-rays, ultrasound, etc.).

Hydraulic testing must be performed by an experienced technician. The repair must be reported to the Ministry (LATU) along with the corresponding inspection report.

Tubes can be removed, provided that their percentage does not affect circulation, create gas passages, or reduce the boiler's capacity.

Tubes can be removed with plugs (in some cases, provided there is no problem with overheating of the plate and plug) or with dummy tubes (a closed section of tube, mandrel-bored in place of the burned-out tube).

In some cases, refractory material must be used to seal the plugs or passages left by the burned-out tube.

Names of associations involved in boiler construction and operating standards.

In our country, the Eastern Republic of Uruguay, there are standards and regulations established by the Ministry of Industry and Energy, the Ministry of Labor and Social Security, the State Insurance Bank, some Departmental Governments, the Fire Department, UTE (the state-owned electricity company), UNIT (the Uruguayan Institute of Technical Standards), LATU (the Technological Laboratory of Uruguay), etc.

These standards and regulations do not cover all those necessary for boiler manufacturing, including references to materials, construction conditions, treatments, and quality controls. Therefore, when requesting the construction or repair of a boiler, we must ask which standards (and organizations) govern the aforementioned items.

These associations or standards names are:

American Standards:

ASME - American Society of Mechanical Engineers. ASME Boiler and Pressure Vessel Committee (Section of the previous society that deals with boilers and pressure vessels).

ABMA - American Boiler Manufacturers Association. Which accepts the standards of the previous society.

ASTM - American Society for Testing and Materials.

AGA - American Gas Association.

ANSI - American National Standards Institute, Inc.

NEMA - National Electrical Manufacturers Association.

NFPA - National Fire Protection Association.

UL - Underwriters Laboratories, Inc. AWG - American Wire Gauge.

SBI - Steel Boiler Institute.

NEMA - National Electrical Manufacturers Association.

AWS - American Welding Society, Inc.

ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers.

ASA - American Standards Association, etc.

Argentine Standards: IRAM.

European Standards:

NBN - Belgian Standards.

VDTUV - German Standards.

BRITISH - English Standards.

ABG-28 - Danish Standards.

CECT - European Recommendations.

Other standards that may be considered:

TDR - Technical Rules for Steam Boilers

DIN - German Industrial Standards, etc.

ISO - International Organization for Standardization.

BS - British Standards.

SAE - Society of Automotive Engineers

AISI-American Iron And Steel Association

AWWA-American Water Works Association.

NEWWA-New England Water Works Association, Etc.

BOILER EXPLOSION DUE TO LOW WATER LEVEL